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Lead Scientist's Report

Summary: This report includes six items: (1) Summary of a *State of Bay Delta Science 2016* journal article on the effects of nutrients on primary producers in the Delta; (2) Article on the evidence for a shift in the shallow water fish community of the Sacramento-San Joaquin Delta; (3) Summary of the report on updated sea-level rise science for California; (4) Highlights from the first meeting of the committee on Grand Challenges and Opportunities in Environmental Engineering and Science in the 21st Century; (5) Highlights from the workshop on Constituents of Emerging Concern and Aquatic Ecosystem Monitoring; and (6) "By the Numbers" summary.

San Francisco Estuary and Watershed Science, Special Issue: *The State of Bay Delta Science 2016 - Nutrient Dynamics of the Delta: Effects on Primary Producers.* Dahm, C. N.; Parker, A., E.; Adelson, A., E.; Christman, M., A.; Bergamaschi, B., A.
This review paper examines a variety of issues linked to nitrogen and phosphorous in the Delta. The issues range from interactions between nutrients and harmful algal blooms to technological advances that enable continuous measurement of nutrients in Delta waters. Within the Delta, nutrient levels have been found to be relatively high, nutrient limitation has been rare, and there is a lower than expected amount of open water primary productivity, commonly attributed to light limitation due to the low clarity of Delta waterways. Hypotheses about the roles that nutrients play in the Delta have changed over the past decade with additional opportunities to advance our understanding of nutrient dynamics in the Delta when a major upgrade of the Sacramento Regional County Sanitation District's wastewater treatment plant is completed in 2021.

The Sacramento and San Joaquin rivers supply a major portion of the nutrients to the Delta annually. Sources of nutrients include natural sources, fertilizers, and municipal discharge. The abundance of both nitrate (an inorganic form of nitrogen) and phosphorous in river water are seasonally dependent. The highest concentration of nitrate is found in water bodies during winter months (when there is increased runoff), and maximum phosphorous concentrations are found in the fall (when more sediment is mobilized and transported to the Delta). Nutrient levels often decrease once they enter the Delta. This is especially true when nutrients have high residence times (the average time in which a given substance is in a particular location) that occur during times of low river flow. This provides more chances for the uptake of nutrients by aquatic organisms.

Much of the open water of the Delta has been termed a "high-nutrient, low-growth" environment, where there is generally low phytoplankton biomass despite high levels of nutrients. Waters of the Delta, however, have become increasingly clear in recent decades and algal blooms are increasingly occurring when the right conditions are met. These blooms include both blooms of desirable forms of algae (e.g. diatoms) and nuisance species (e.g. cyanobacteria). The roles for nutrients in both desirable and harmful algal blooms are important areas of ongoing research.

High levels of nutrients, when Delta water temperatures are warm, days are long and clear, and water residence time is long, contribute to the formation of harmful algal blooms in the Delta. As blooms of harmful cyanobacteria "die" their decomposition can cause hypoxic (low oxygen) or anoxic (absence of oxygen) conditions, which can be lethal to other aquatic organisms. Additionally, some noxious algal blooms produce harmful toxins that pose a risk to both wildlife

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and humans. Additionally, there is an economic impact of harmful algal blooms because contaminated waters are costly to treat and may affect tourism. The causes of these harmful blooms are varied, but are often linked to periods following high water flow (in which a large amount of nutrients are brought into the system) followed by a period of low flow (in which nutrients have a longer residence time in the water). In the Delta, the most common cyanobacteria that produces these harmful blooms is *Microcystis*, which uses ammonium as its primary source of nitrogen to facilitate growth and which thrives in warm, clearer waters.

The spread of invasive aquatic vegetation, namely Brazilian waterweed, water hyacinth, and water primrose, within Delta waterways is another pathway by which nutrients might be playing a role in water quality within the Delta. These non-native species greatly impact the use of waterways for commercial and recreational purposes, alter aquatic habitat, and negatively impact many native Delta species by affecting the availability of crucial food resources. Consistent monitoring of the spatial coverage of invasive weeds in the Delta will provide insights into how management of nutrients in affected waterways influences the proliferation of unwanted aquatic weeds.

The 2021 upgrades to the Sacramento Regional County Sanitation District's wastewater treatment plant will substantially reduce the ammonium and total inorganic nitrogen input within the Delta. This improvement in water quality will provide researchers with an opportunity to trace effluent nitrogen in the system both before and after the plant upgrade and to study the transport, uptake, transformation, and role of effluent nitrogen in food webs. To advance understanding of nutrient dynamics in the Delta, future research needs include: 1) understanding the effects of the upgraded Sacramento Regional Wastewater Treatment Plant on food webs in the Delta; 2) linking established hydrodynamic models with water quality models to better understand the transport of nutrients; 3) investigating how wetland restoration within the Delta will affect nutrient biogeochemistry; and 4) combining metabolism measurements of aquatic ecosystems with continuous nutrient sensor data to better understand nutrient uptake. The Council has taken initial steps to implement a number of studies, collectively referred to as Operation Baseline (funding for which was approved by the Council at the April 2017 Council meeting), to initiate research that addresses these needs.

Evidence of a Shift in the Littoral Fish Community of the Sacramento-San Joaquin Delta
Mahardja,B., Farruggia, M.J., Schreier, B., Sommer, T.
PLoS One, 12(1): e0170683. January 2017.
http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0170683

In the early 2000s, the Delta experienced a severe collapse in the abundance of fish in the open water (not near the bottom nor near the shore). This is known as the pelagic organism decline. The causes of this decline are much discussed and debated. One possible cause is the notable shift in the food sources for these fish. These changes are often referred to as alterations to the Delta food web. There has been limited research, however, on the status of the fish that inhabit waters close to the shore. This region is known as the littoral zone. To determine changes in the Delta fish community that lives in the littoral zone, the authors examined data from near-shore fish surveys collected from 1995 to 2015 from 26 sites in the Delta.

What has happened to the fish communities that live near the edges of the waterways of the Delta? From 1995 to 2015, in contrast to fish in open water, fish near the shores of the Delta increased in abundance. Of the 23 fish species analyzed, 11 increased in abundance, two declined, and there was no change for the remaining 10. Introduced (non-native) fish showed

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the most consistent increase in abundance. The factors that led to these increases appear to differ between fish species. Some increased due to changes in plant communities and food webs, while other species responded to changes in flow. A doubling in biomass, or weight caught per area studied, was also observed. This increase was mostly driven by a handful of introduced fish species including the Mississippi silversides.

Over this 20-year period, there has been a steady change in the make-up of the littoral fish community in the Delta, providing evidence for a shift in the structure of this component of the ecosystem. Notably, fish biomass in the littoral zone has doubled over 20 years of monitoring. This doubling is driven by a handful of fish species from the Mississippi drainage that are now widespread in the Delta. The authors suggest that as littoral tidal habitat in the Delta increases, there is a strong likelihood that littoral fish abundance will also increase. What remains uncertain is whether these new tidal habitats would favor native fishes or the already numerous non-native fish species. The fish communities of restored tidal wetlands need to be monitored carefully to see how native and non-native fish species respond.

Summary of *Rising Seas in California – An Update on Sea-level Rise Science*
On April 17, 2017, the California Ocean Protection Council (OPC) and the California Natural Resources Agency, in collaboration with the Governor's Office of Planning and Research and the California Ocean Science Trust, published a report updating the state of science on sea-level rise (SLR)[1][2] to provide guidance for incorporating sea-level rise projections into its planning, investments, and other decisions. The previous California SLR document (adopted in 2010 and updated in 2013), only provided guidance to State agencies. This updated document, however, incorporates guidance for city and county governments. Broadly, the report can be summarized by its seven key findings:

1) *Scientific understanding of SLR is advancing at a rapid pace. Future projections under high emissions scenarios for greenhouse gases, have increased substantially over the last few years, primarily due to a new and improved understanding of mass loss from continental ice sheets.*
2) *The rate of ice loss from the Greenland and Antarctic Ice Sheets is increasing. These ice sheets will soon become the primary contributor to global SLR, overtaking the contributions from ocean thermal expansion and melting mountain glaciers and ice caps.*
3) *Mountain glaciers contain enough ice to raise sea levels by only about 1.5 feet, whereas the Greenland and Antarctic ice sheets contain enough ice to raise global mean SLR by 24 feet and 187 feet, respectively.*
4) *For California, ice loss specifically from West Antarctica causes higher SLR than in the global average. For every one foot of global SLR caused by loss of ice on West Antarctica, sea-level rise will be approximately 1.25 feet along the California coast.*
5) *After 2050, SLR projections increasingly depend on the trajectory of greenhouse gas emissions.*
6) *While model results have revealed the potential for high rates of ice loss and extreme SLR during this century if greenhouse gas emissions continue unabated, the precise magnitude*

[1] Link to full Update on Sea-Level Rise Science document: http://www.opc.ca.gov/webmaster/ftp/pdf/docs/rising-seas-in-california-an-update-on-sea-level-rise-science.pdf

[2] Link to one-page Update on Sea-Level Rise Science summary: http://www.opc.ca.gov/webmaster/_media_library/2017/03/1-Pager_Updating-Californias-Sea-level-Rise-Guidance.pdf

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and timing of when the Antarctic Ice Sheet may begin to contribute substantially to rising seas levels is still uncertain.

7) *As cities, countries, and state agencies make decisions about adaptation and hazard mitigation, it is increasingly important to incorporate long-range planning for SLR. Consideration of high and even extreme sea levels in decisions with implications past 2050 is needed to safeguard the people and resources of coastal California.*

In addition to these seven key findings, the report stresses that waiting for scientific certainty is "neither a safe nor prudent option", especially in light of new SLR projection rates that are 30-40 times faster than the SLR experienced over the last century. A synthesis of the SLR report was presented at the April 26, 2017 California OPC meeting in Sacramento, serving as the beginning of a public engagement process that will last throughout 2017 and culminate in the adoption of a final guidance document by OPC (scheduled for January 2018).

Committee on Grand Challenges and Opportunities in Environmental Engineering and Science for the 21st Century

The Delta Stewardship Council (Council) is one of the sponsors of a new study by the National Academy of Sciences, Engineering, and Medicine on Grand Challenges and Opportunities in Environmental Engineering and Science for the 21st Century. Cliff Dahm, Delta Lead Scientist, presented (via WebEx) at the committee's first public meeting in Washington, D.C. on Thursday, May 4 with Council Chair Randy Fiorini, Special Assistant for Policy and Science Jessica Law, and Deputy Executive Officer for Science Rainer Hoenicke listening in. The study committee is made up of 18 preeminent scientists and engineers with expertise in environmental engineering, environmental science, or a closely allied field of study. Four of the study committee members have strong California ties, and two members of the committee are from California (Thomas C. Harmon, University of California, Merced, and Rhodes Trussell, Founder and Chairman of Trussell Technologies, Inc., in Pasadena).

The opening session began with a welcome and overview from the Committee Chair, Domenico Grasso of the University of Delaware. The study sponsors (The National Science Foundation, the Department of Energy, and the Council) then answered the following three questions: 1) What is your agency's interest in this study; 2) How will the study be useful to your agency; and 3) What key issues or perspectives would you like the committee to consider? The sponsors and invited experts then began a discussion with the committee focusing on major challenges that need to be addressed in the next few decades at the nexus of crucial topics such as environmental and public health, sociology, infrastructure development, energy generation, and food production.

Participation in this grand challenges effort was the vision of former Lead Scientist Dr. Peter Goodwin. Dr. Goodwin felt strongly that California faces many grand challenges in environmental engineering and science and that the state should be an important player in the national dialogue. The second meeting of the study committee will be in California in September 2017. Council staff plan to play an important role in both helping host the committee and informing the committee of California issues in these fields of study. Ultimately, the committee's goal is to address how the fields of environmental engineering and science, including education and training of the next generation of practitioners, might need to evolve to better meet the identified grand challenges. The final product from the committee will be a report similar in form to the high impact National Academy of Engineering Grand Challenges for Engineering issued in 2008.

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Workshop on Constituents of Emerging Concern and Aquatic Ecosystem Monitoring
A two-day workshop that presented the most recent information regarding contaminants of emerging concern (CEC) in the Bay-Delta and other areas of California was held May 1-2, 2017. CECs are chemicals such as personal care products that are not regularly monitored, but may have the potential to have adverse ecological and/or human effects. The CEC workshop was a response to a pilot plan developed by the California State Water Resources Control Board (Water Board) for a comprehensive statewide CEC monitoring effort to provide baseline information to help guide management actions. The Central Valley Regional Water Quality Control Board (Central Valley Regional Water Board), with input from stakeholders, will be developing a pilot CEC monitoring study with a focus on wastewater and stormwater agencies in the Delta. Information gathered from these efforts will be used to inform the aforementioned statewide monitoring approach.

The purpose of the workshop was to provide information to guide the proposed monitoring studies for wastewater and stormwater in the Delta. Day one was devoted to providing an overall assessment of monitoring efforts throughout the state, lessons learned from these efforts, discussion of current and emerging monitoring methods, and remaining knowledge gaps. The second day was focused specifically on the Delta and featured discussion of various management drivers for CEC monitoring and feedback from participants on proposed monitoring plans for both wastewater and stormwater. In the following weeks both the Central Valley Regional Water Board and the Water Board will take the information gathered during this workshop and coordinate with wastewater and stormwater groups to further develop the monitoring plans.

Meeting agendas from the workshop can be found at:
http://www.waterboards.ca.gov/centralvalley/water_issues/waste_to_surface_water/hot_topics/

By the Numbers
Delta Science Program staff will give a summary of current numbers related to Delta water and environmental management. The summary (Attachment 2) will inform the Council of recent counts, measurements, and monitoring figures driving water and environmental management issues.

List of Attachments

1. By the Numbers Summary *(report to be provided at the Council Meeting)*

Contact

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